Chapter 1
A Contextualised Multi-Platform Framework to Support Blended Learning Scenarios in Learning Networks

Tim de Jong
Open University of the Netherlands, The Netherlands

Alba Fuertes
Technical University of Catalonia, Spain

Tally Schmeits
Open University of the Netherlands, The Netherlands

Marcus Specht
Open University of the Netherlands, The Netherlands

Rob Koper
Open University of the Netherlands, The Netherlands

ABSTRACT

This chapter describes a multi-platform extension of learning networks. In addition to Web- and desktop-based access, the authors propose to provide mobile, contextualised learning content delivery, and creation. The extension to a multi-platform extension is portrayed as follows. First, the authors give a description of learning networks, the kind of learning focused at, and the mechanisms that are used for learner support. After that, they illustrate a possible extension to contextualised, more authentic forms of learning mediated by mobile devices. Moreover, they give some requirements for a multi-platform learning network system and describe a technical framework integrating contextualised media with learning networks. Two blended learning scenarios are given as examples of how the extended system could be used in practice. Last, the conclusions and outlook describe what is necessary to integrate multi-platform e-learning software in existing learning scenarios, and how a larger-scale adaptation can be achieved.

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INTRODUCTION

Lifelong learning takes place anytime and anyplace. Next to formal learning scenarios in a classroom, a great deal of learning is informal, happening in unforeseen places and at unexpected times. Recent developments in mobile technologies increasingly make it possible to support learning on the move and make use of these spontaneous learning situations. Moreover, mobile technology offers new chances to integrate spontaneous learning in a more formal learning scenario. Already, we see a tendency to use blended learning scenarios combining different forms of learning, and integrating various ways of content access; for instance, web-based, desktop, and mobile. A couple of mobile projects aim at a better integration of mobile learning scenarios into more formal, classroom-based scenarios. MyArtSpace (Sharples, et al., 2007), for example, strives for an easier combination of a museum trip with lessons before and after the visit. Similarly, the RAFT project (Terrenghi, Specht, & Moritz, 2004) endeavoured to improve the benefit of museum visits by mediating the communication between learners on location and learners in the classroom. Furthermore, the Sydney Olympic Park Project (Brickell, Herrington, & Harper, 2005) is a more recent blended learning example. In this sense, mobile technology can be seen as a mediating artefact (Sharples, 2007) that (1) can be used to give more structure to informal learning, and (2) integrates informal learning into blended learning scenarios.

The combination of learning inside as well as outside the classroom calls for a range of different, specialised devices, each suited for a specific learning use and provided with device-specific client software wielding their potential for learning. Moreover, blended learning scenarios call for software integrating the use of these devices. With the introduction of new multi-faceted devices the possibilities for content creation, delivery, and sharing across different learning contexts has been possible. Mobile devices facilitate personalised and contextualised services that provide new ways of supporting, for example, authentic and workplace learning situations (Collins, Brown, & Newman, 1989; Schön, 1983; Sticht, 1975). In addition, mobile technology can be used to engage the learner and include her in the social and cultural aspects of that learning process (Bruner, 1996; Paiget, 1970). However, some learning content can be better used on devices with larger screens, like desktop PCs and smartboards, which provide better opportunities to display and create larger pieces of content.

Still, although blended learning scenarios are seen more frequently, it does not seem to be adapted on a larger scale in modern-day teaching. More importantly, most of technology use in education is seen as interrupting education (Sharples, 2003) and the potential of it is therefore often discarded. Additionally, the technology itself can provide an insurmountable hurdle: for instance, the mobile market contains lots of different devices without much standardisation, which leads to a need for detailed technical knowledge to be able to integrate mobile technology in existing learning scenarios. Moreover, the rapidly changing technologies form an additional burden to keep the learning scenarios up-to-date; even worse, while most learning designs would remain the same and would need similar functionality, this would have to be implemented again and again for new technology. Last, small-scale experiments could be used to create enthusiasm and show the benefits of mobile, ubiquitous, or blended learning to teachers, learners, and institutions. The creation of such experiments calls for flexible and fast prototyping, and by giving the opportunity to create and integrate learning technologies fast and without too much effort, the number of applications would increase, making room for new and innovative learning approaches.

Thus, we believe the issues preventing a larger scale adoption of new technology for learning could be mostly tackled by simplifying the use, as well as, the integration of learning technologies in modern day education. In our opinion, a standardised, technology-supported process of installation, use, and integration would benefit a larger scale adoption of multi-platform learning systems and makes it possible to reuse and adapt existing learning designs in multiple learning contexts. Certainly, ease of use would lead to a greater enthusiasm to adopt new forms of education, which in its turn could increase the frequency of use. Therefore, we will illustrate a standardised process of creating authentic, blended, and ubiquitous learning scenarios and describe a technical infrastructure to help design these scenarios. More importantly, the technical infrastructure will provide generic interfaces and components that should ease the use with a range of devices and, furthermore, hide the technical details to reduce design complexity.

However, the design of an infrastructure for multi-platform, ubiquitous learning has to be grounded in theory. Consequently, in the next section, section two, we will first consider existing learning networks, the underpinning pedagogical theories, and how the pedagogical scenarios used could be extended with mobile devices. Section three describes an extension to learning networks to support blended learning with authentic real-world scenarios, which subsequently leads to technical requirements that will be described in section four. After that, a technical framework is considered in section five and illustrated using two learning scenarios in section six. Last, section seven provides our conclusions and an outlook to future developments.

Learning Networks

Learning networks (Koper, & Tattersall, 2004) are social software that support networks of lifelong learners, focusing at communities of self-directed learners. More importantly, they mean to exploit the heterogeneity of learners by creating communities where novices and experts can collaborate. Learning networks are founded on a combination of social-constructivist theories, more specifically, lifelong learning theories that integrate informal and formal learning approaches. Hence, to facilitate this integration, learning network software concentrates on supporting:

- Self-directed learning
- Learning in communities-of-practice
- Learning content creation, organisation and delivery

In the next subsections, we will shortly consider how learning network software supports these three settings, and see how learner support could be extended with mobile technology in a multi-platform e-learning system. In addition, we look at blended learning theory to extend current pedagogies in learning networks to include more authentic, real-world scenarios. After all, lifelong learning is learning anywhere and anytime and a supporting platform should ideally combine a variety of learning technologies to get the best out of each learning opportunity.

Self-Directed Learning

A lifelong learner is most often a self-directed learner (Brockett, & Hiemstra, 1991). Therefore, learning networks provide help for learners to self-organise their learning. A specific example of learner support are recommender systems that help learners deriving a learning path, a sequence of units of learning that would ultimately result in acquiring a learning goal (Drachsler, Hummel, & Koper, 2008). Another example of assistance for self-directed learners is assessment support that helps them position themselves on a learning path; i.e. which units of learning do they still need to carry out, and which ones they can skip (Kalz, et al., 2007). Furthermore, learning network software assists these learners to reflect (Schön, 1983; Schön, 1987) about their learning by preserving their growth in competency (Koper, & Tattersall, 2004). The learners *controlling* their own learning process is also specifically mentioned as a part of a task model for mobile learning presented in (Taylor, et al., 2006); thus, mobile learning could provide new ways of self-directed learning by facilitating learning content access nearly anyplace and anytime.

Learning in Communities-of-Practice

Next to self-directed learning, learning networks, as the name already states, support learner communities on a certain topic. The pedagogical theory underlying learning networks is mainly given by Wenger and Lave (Wenger, & Lave, 1991) who stressed the importance of knowledge acquisition in a cultural context and the integration in communities-of-practice. Bruner (Bruner, 1996) additionally states that learning should include social and cultural aspects. Hence, learning networks are social software for learning that provide several mechanisms to build, support, and maintain community processes in such communities-of-practice, among the most important are the following.

First, *collaboration:* Wenger and Lave (Wenger, & Lave, 1991) stated that learning requires collaboration, preferably in a heterogeneous group of learners, where novices can learn by interaction with experts. Communities in learning networks provide a central place for people to collaborate on joint learning tasks. Especially, these communities play an important role in finding appropriate peers to collaborate with and ideally lead to learners helping each other out.

Second, another important mechanism is technology-assisted *community reflection,* which allows a learner to find suitable learning peers, but also contrasts the learner's own experience to that of the community. Community-reflection makes it possible for learners to find experts to learn from, help out less experienced learners, or collaborate with learners that have similar backgrounds and are facing similar problems in their learning. For this reason, learning networks preserve a learner's action history, more specifically a record of their competence development, which can be used to position themselves in relation to others in the learning community. This is one type of social awareness which is aimed at sparking and maintaining active collaboration. Whereas learning networks provide technical assistance to raise social awareness, most of this assistance is meant to support web-based communities. In this sense, mobile technology could provide a link to real-world settings; an interesting approach being the BlueAware system presented in (Eagle & Pentland, 2005), which raises social awareness by notifying users when someone with similar interests is nearby.

Third, learning network software encourages *communication* between learners. Pask's conversation theory (Pask, 1975) states that learning occurs by using conversations to make knowledge (more) explicit. In addition, Wenger & Lave (Wenger & Lave, 1991) endorse the importance of communication by articulating that learning requires social interaction between peers. Moreover, according to Cognitive Flexibility Theory (Spiro, et al., 1992; Spiro, & Jehng, 1990), learning activities must provide multiple representations of content and support context-dependent knowledge. Especially, the theory identifies the importance of using interactive technology to support the learner in the learning process. The various opinions of learners represent multiple perspectives on learning content. Therefore, learning networks offer several communication channels between peers; this makes various forms of reflection possible, for example, learning by comments made by a peer, or learning by creating comments on knowledge created by another learner. One way mobile devices can extend the range of possibilities is by allowing communication between situated learners in an authentic learning situation and de-contextualised learners in a classroom or learning network (Terrenghi, Specht, & Moritz, 2004).

Learning Content Creation, Organisation and Delivery

In a review of new learning and teaching practices, Nesta Futurelab identified several pedagogical theories underpinning current learning technologies (Naismith, et al., 2004). One specific role of technology they found was assisting learners and teachers in coordinating learning and resources in learning activities. In learning networks, the coordination is mainly aimed at supporting self-directed learning and learning in communities of practice as we already have seen before. Next to that, learning network software makes available means to coordinate learning content creation, organisation, and delivery.

Learning content creation: constructivist theory (Bruner, 1966) brings forward learning as an active process, in which learners should construct new ideas or concepts based on their current knowledge. Moreover, learning has to take into account experiences and contexts that make the student willing and able to learn. Learning networks consist of learners that create their own learning content and provide that learning content to be used and improved by the community. Mobile and instant creation of learning content with associated context information, like for example GPS coordinates, has already been demonstrated in for example (De Jong, Specht, & Koper, 2007) and provides unique possibilities to add authentic learning content to learning communities.

Learning organisation: several pedagogical theories emphasise that instruction must be structured to be easily grasped by the student (Brockett, & Hiemstra, 1991; Bruner, 1966; Bruner, 1996). Furthermore, learning must not only be planned structured by a curriculum but also by the tasks and learning situations, and the interaction with the social environment of the learner (Wenger & Lave, 1991). Learning networks offer extensive support to organise learning based on units of learning, learning paths and pedagogical scenarios specified in IMS-LD (Drachsler, Hummel, & Koper, 2008; Koper, Olivier, & Anderson, 2003; Koper & Tattersall, 2005). Related to that, cognitive apprenticeship (Collins, Brown, & Newman, 1989) stresses the importance of structuring authentic learning processes to guide learners towards appropriate levels of knowledge by a constant process of contextualisation and de-contextualisation of knowledge. An interesting example providing learning organisation in a lifelong learning scenario that includes mobile devices is given in (Vavoula, & Sharples, 2002).

Learning content consumption: from a constructivist point of view knowledge is always contextualised, e.g. learning is always situated within its application and the community-of-practic (Mandl, Gruber, & Renkl, 1995). Furthermore, approaches like reflection in action and reflection about action describe the relevance of the context for enabling learning and self-reflection (Schön, 1983; Schön, 1987). While learning in learning networks is contextualised in the sense that it is situated in communities of practice, learning content is still mostly presented out of its situational context; i.e., the authentic context the knowledge needs to be applied in. An extension to contextualised mobile media could help to assist the learner in these authentic situations, by tailoring information delivery to an authentic learning context (Bardram, & Hansen, 2004; Klopfer, Squire, & Jenkins, 2002; Ogata, & Yano, 2004).

Blended Learning Scenarios

The integration of formal and lifelong learning approaches with informal learning activity support in learning networks is currently investigated in the TENCompetence project (Koper, 2005). While the learning networks in this project provide multi-platform access to learning content, and hence the possibility to implement blended learning scenarios, the project focuses at web-based and desktop delivery of learning content. With the recent uptake of mobile devices (Castells, et al., 2007), mobile information access has be-come more and more important. In addition, this new technology's impact on communication and learning in the younger generation is described as highly relevant for new forms of learning support (Green, & Hannon, 2007). However, the integration of mobile device technology and other new learning media with learning networks, such as smart phones, tablet PCs, smartboards, and gaming consoles, is mostly left out of scope. Moreover, the contextualisation of the learning content is limited. Since mobile devices offer unique possibilities for contextualised content creation and delivery, an extension with mobile devices would therefore offer the possibility to add real-world, context-specific learning scenarios in learning networks.

Several experts have indicated that learning should happen in relevant scenarios, situations, or contexts. Wenger and Lave (Wenger & Lave, 1991), for example, state that learning in a community-of-practice should use authentic tasks and learning situations, i.e., settings and applications that would normally involve the knowledge learnt. Sticht (Sticht, 1975), shares their emphasis in addressing the need to make learning relevant for the work context. Moreover, he states that the assessment of learning requires a context/content specific measurement. Related to that, Piaget (Paiget, 1970) highlights that learning should take place with activities or in situations that engage the learners and require adaptation. Teaching methods should be used that actively involve students and present challenges to the learner.

In a recent literature review of mobile contextualised software (De Jong, Specht, & Koper, 2008b), the authors made apparent that mobile devices have already been used to a large extent for social learning appliances. In particular, five application types of mobile social software for learning were exposed:

- Sharing content and knowledge
- Facilitate discussion and brainstorming
- Social awareness
- Guide communication
- Engagement and immersion

As we can see, the emphasis of mobile social software is quite similar to those of learning networks. A multi-platform learning system combining learning networks with mobile devices seems straightforward to create. In such a multi-platform approach to learning the benefits of both approaches would come together: on the one hand, self-directed learning and learning in communities-of-practice supported by the learning networks software. On the other hand, the learning content and learner interaction in learning networks can be extended with authentic, real-world creation, delivery, and interaction via mobile devices. In this way, blended learning scenarios could be created, integrating a range of technology, using the best technology to support a certain task in a certain situation or context: for instance, a mobile device to support on-the-spot learning in a field trip, or a smartboard to display learning content to a classroom full of learners.

A blended learning scenario that integrates mobile learning combines de-contextualisation and contextualisation of knowledge; theoretical knowledge learnt in a classroom setting could be transferred into practical knowledge in a real-world scenario. Moreover, through using context information, in combination with the creation or retrieval of learning content, several educational effects can be achieved:

- *Multiple perspectives on real-world objects*: by viewing and creating content in a real-world context, several opinions can be perceived and expressed, from which people can benefit through an indirect learning process (Efimova, & Fiedler, 2004).
- *Community-generated content* connected to relevant real-world objects and locations; an example for the effect and importance of self-generated contents in a learning community is presented in (Brandt, et

Table 1. A reference model for mobile social software

Content	Context	Information flow	Pedagogical model	Purpose
Documents Annotations Messages Notifications	Individuality Context Time Context Locations Context Environment or Activity Context Relations context	One-to-one One-to-many Many-to-one Many-to-many	Behaviourist Cognitive Constructivist Social Constructivist	Sharing Content and Knowledge Facilitate Discussion and Brainstorming Social Awareness Guide Communication Engagement and Immersion

al., 2002) about learning to operate medical devices.

- *Community interaction* and the creation of communities of interest around certain objects and locations, supporting contextualised learning (Wenger & Lave, 1991).
- *Different views on objects based on personal preferences*. Real-world objects can also be linked electronically to create relations between those objects and to create a so-called "internet of objects" (Mattern, 2004).
- *Recording of learning events;* allows for later reflection and eliciting of expert's knowledge, carried out in a work context during or shortly after the actual action performed (Schön, 1983; Schön, 1987).
- *Learning content tailored to a specific learning activity*; in the sense of cognitive apprenticeship (Collins, Brown, & Newman, 1989) the learner is guided towards appropriate levels of knowledge by a constant process of contextualisation and de-contextualisation of knowledge. Cognitive apprenticeship furthermore assumes this guidance takes place in an authentic learning situation.
- *Increasing motivation through active learning*, by actively involving the learner in the learning process, the learner involvement and motivation is increased. This as opposed to passive learning in a formal, classroom setting (Bruner, 1966).

Summarising, contextualised media enables the learner to create, retrieve, and use digital media in a relevant real-world context for notification, documentation, problem solving, reflection, communication and a variety of other learning activities. In the next sections, a technical extension of learning networks with contextualised mobile media will be laid out, to facilitate blended learning scenarios that combine social learning in learning networks with authentic scenarios in the real-world.

Extending Learning Networks with Contextualised Blended Learning Scenarios

In an earlier paper (De Jong, Specht, & Koper, 2008b) the authors have presented a reference model that can be used as a basis for future applications of mobile learning. The model will be used to extend the presented learning networks model to include context-aware mobile applications, which makes it possible to define contextualised blended learning scenarios in authentic settings. An overview of the reference model for mobile social software has been shown in Table 1, which combines each of the identified dimensions with its possible values.

The reference model describes the type of content that is used in contextualised learning tools, the context parameters taken into account for adaptation, the information flow, and on a higher level the main purpose and the underpinning pedagogical model.

- The content dimension describes the artefacts exchanged and shared by users, in an analysis of the literature the main types of artefacts found were annotations, documents, messages, and notifications.

- The context dimension describes the context parameters taken into account for learning support. The main context dimensions identified are based on an operational definition of context by Zimmermann, et al. (Zimmermann, Lorenz, & Oppermann, 2007).
- The information flow classifies applications according to the number of entities in the system's information flow and the information distribution.
- The pedagogical paradigms and instructional models describe the main paradigm leading the design of contextualised media and the integration of media in real world contexts.
- The purpose describes applications according to the goals and methods of the system for enabling learning.

Using the reference model, mobile learning systems can be compared and classified by looking at the five dimensions; while one system could combine documents and annotations with locations context and a one-to-one information flow to support a learner in self-reflecting on the actions carried out in a specific location, another one with a many-to-many information flow would enable community-reflection for a group of learners. Thus, on the one hand, the reference model describes the manipulated knowledge resources, the context in which they are used, and the different flows of information. On the other hand, the higher level concepts of pedagogical model and purpose define how the content, context, and information flows are used and combined. The combinations of different values for each dimension lead to various forms of contextualised software with different purposes and different pedagogical underpinnings. Yet, the five dimensions should be seen as fairly independent. Despite the fact that they can be used to classify and derive applications of mobile learning, a specific combination of context, content, and information flow does not clearly specify the pedagogical model or purpose of the application. Still, some combinations of dimensions may be encountered more often than others for a certain pedagogical model or purpose. As an example, a system with a main purpose of *sharing content and knowledge* between its users, will most often use *documents* from the content dimension, *relations context* to describe social relations between the users, and a many-to-many information flow. Likewise, a social constructivist system like RAFT (Hine, Rentoul, & Specht, 2003), combines on-the-spot creation and delivery of documents with locations context, and messages between learners in a many-to-many information flow for increased engagement and immersion.

Learning network software is structured in four layers (Koper, 2005) that can be described using the dimensions content, information flow, and pedagogical model in the reference model described above. In addition then, the learning network model can be extended to include all aspects of the context dimension of the reference model. The four layers in a learning network can be mapped onto the reference model as follows:

- Knowledge Resources are reusable and self-contained pieces of learning content addressing a part of a larger course. These can consist of a variety of documents and annotations of the content dimensions.
- Units of Learning combine Knowledge Resources into Learning Designs that are underpinned by one of the pedagogical models of the reference model. The pedagogical scenarios are made up out of tasks and activities that can be described in a standard like IMS-LD (Koper, Olivier, & Anderson, 2003; Koper, & Tattersall, 2005). Learning designs furthermore can use the notifications of the content dimension to inform the learner about tasks and activities.

- Learning Communities consist of groups of learners interested in one specific topic and can be specified using individuality context, relations context, and the information flow between learners. Learners can communicate using the messages of the content dimension.
- A Learning Network is a collection of communities on a similar topic and can be fully described using the previous layers.

To be able to include authentic learning scenarios in the real-world would entail adding several additional context parameters to a learning network system and extending others to include more detailed information. Most notably, a learning network that includes learning in the real-world should be able to handle locations, time, and environmental or activity context. These three kinds of context can, together with the other forms, be combined to describe the learning situations (Dey, 2001) a learning scenario would take place in. For example, a history lesson could take into account certain historic locations that could be used to support field trips to those locations. More importantly, by defining more generic situations “in a restaurant”, reusable scenarios can be defined that can be used to learn in a range of similar situations.

Technical Requirements for using Contextualised Media in Learning Networks

However, to make a seamless integration of learning networks with for mobile and contextualised technologies possible, the implementation of the software for the technologies should be based on existing standards and should additionally take into account the following requirements.

Multi-platform e-learning systems need to provide access to learning content from a wide range of devices, which requires a flexible technical infrastructure that is focused on *standardisation* and *reusability*. Technical standardisation will make the integration with existing learning management systems easier, and simplify the exchange of information between different devices and technologies. A client-server architecture adhering to existing web service standards is another kind of standardisation that will ease the interaction between heterogeneous devices and enable distributed technology (smartphones, iPods, desktops, smartboards) to communicate in a standardised and similar way.

All in all, standardisation is important because of information interchange between a variety of systems. In addition, standardisation makes the reuse of content easier. Next to the reuse of the learning content itself, pedagogical scenarios that integrate several situations, technologies, and learning theories should be written in reusable learning designs, specified in a standard like for example IMS-LD (Koper, Olivier, & Anderson, 2003; Koper, & Tattersall, 2005). *A modular server architecture*, in which new functionality can easily be added and integrated within existing learning designs, would increase this reusability.

Accessibility on different platforms calls for generic technical interfaces that make the system accessible from multiple clients. Additionally, accessibility requires adaptation of content to specific platforms; content created on one platform ideally should also be accessible using another. However, not all content is suitable to be displayed on all devices. Therefore, a technical framework supporting multi-platform learning approaches requires a certain flexibility providing *learning content filtering* and *learning content adaptation* to handle various formats and sources of learning content. The learning content should be specified in a device-independent XML format which can be easily translated to a standardised content mark-up language to be rendered for display on various devices.

In addition, *the independence of (mobile) client technology* is important because it allows for a more heterogeneous user group and to some extent circumvents the demands of rapidly changing/aging technology. The use of web-based content furthermore makes it possible to use *light-weight, easily portable clients* that integrate a web-browser to display the learning content and provide device-specific software to provide access to sensors. Next to this, specialised clients could be used for educational uses with a higher demand, when high performance is needed and the strengths of the technology should be exploited.

Finally, the multi-platform e-learning systems should be *easy to use*. This applies to the usability of the client software, but also to the integration of the technology in existing education. One way to realised the latter, is the use of tools aimed at a specific user groups. We propose at least two different user groups: first, one technical user group that manipulates and aggregates lower level information into higher level educational concepts. Second, we suggest an educational practitioner group that uses the educational concepts defined by the first group to create sound pedagogical scenarios. The design of a pedagogical scenario using multi-platform e-learning systems should be left educators, and therefore requires tools that operate on pedagogical concepts that those educators are familiar with. In any case, educators should not be bothered with technological details, and should work with higher level concepts and components designed by people with more technological knowledge.

Technical User Group

The technical user group creates higher level educational concepts for the educational practitioners. These concepts are created by defining aggregations of context information that has been acquired using the sensors. Moreover, certain actions can be defined using actuators.

Ideally, the technical user group would combine existing software components without writing any code. The creation of components should be a special case that only occurs rarely. Instead, the technical user group should be provided with two kinds of tools: (1) a visual aggregation tool that allows them to combine the components graphically, and (2) a rule-base architecture that makes it possible to define more complex component aggregations based on logic conditions about component inputs and outputs.

The technical user group uses the tools to specify both *situations* and *activities,* which can be used to define pedagogical scenarios. Situations are specified by an aggregation of context parameters and values and give the conditions in which a certain activity *can* or *should* take place. Conversely, activities specify certain actions or combinations of actions that should influence or drive learning (Koper, Olivier, & Anderson, 2003; Koper & Tattersall, 2005).

In a driving instruction scenario, a situation and activity could be defined as follows: to teach a student operating the vehicle not to drive too fast, a *situation* called "speeding" could be created that combines the two context *parameters* of time and location. Using the context *values* of these parameters the speed of a person can be calculated. Based on a *condition* defining the situation of "speeding", a decision can be made whether or not to carry out an *activity* that teaches the person what reaction is needed to prevent the person from driving too fast.

Educational Practitioner Group

An educational practitioner designs the pedagogical scenarios aimed at a specific learning content domain. Unlike, the technical user, an educational practitioner should not be bothered with technical details, like aggregations of sensor information and how to define situations on the basis of context parameters. Instead, an educational practitioner should be presented with known pedagogical and domain-specific concepts.

Pedagogical scenarios can be defined using learning designs that can be specified using standards as IMS-LD (Koper, Olivier, & Anderson, 2003; Koper & Tattersall, 2005). Learning designs use a combination of activities and learning content to create a variety of pedagogical scenarios. A lot of standardised activities are present within learning networks, among others the following examples:

- *the study* of learning theory,
- *on-spot content creation*; for example mobile content gathering,
- *community-reflection* on created content,
- *situation-specific* learning content delivery,
- *introduction to suitable learning peers,*
- *collaboration,*
- *discussion with peers.*

To create technology-mediated authentic learning scenarios, the situations in which these activities take place should be furthermore specified. In this case, three different conditions can take place. First, a situation could be pre-condition to an activity, thus, an activity will be sparked when a learner takes part in a situation. Second, a situation could be a post-condition that could be the result of an activity. Third, the situation can be monitored during an activity. By using this combination of activities, situations and learning content, complex learning scenarios can be created, two of which we will describe later.

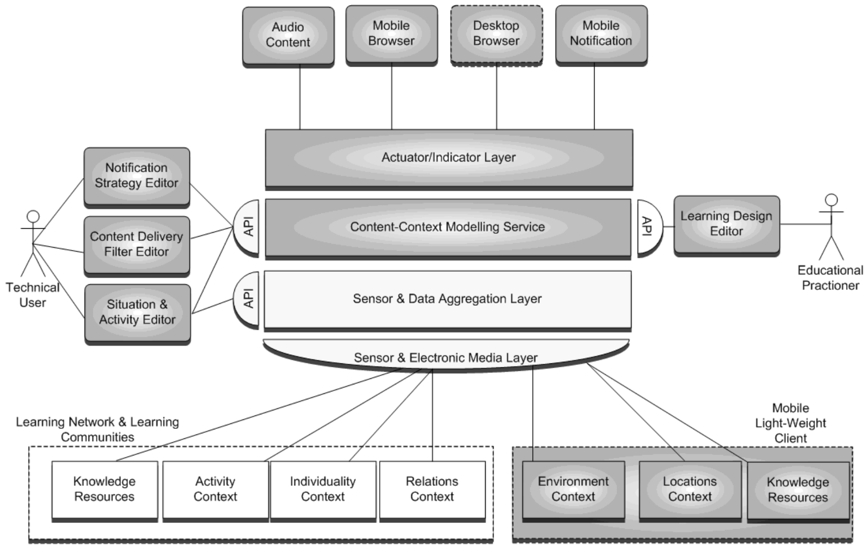
Technical Framework

The requirements formulated in the previous section lead to the development of a modular client-service architecture which takes into account both the requirements for learning network software and a framework for contextualised media. In (De Jong, Specht, & Koper, 2008a) we developed a specification for a technical framework for contextualised media for learning, on the basis of the reference model that can be used as a guideline to implement contextualised learning networks. The framework for contextualised media described a layered software architecture that comprised of four layers, which enriches data step-by-step:

- The first and lowest layer collects the data captured by the client sensors and it acquires the electronic media created by the users. The data in this layer represents the simplest form of data, either *context information*, like for example a user location, or *electronic media*, as for example pictures created.
- The second layer groups the sensor data and electronic media into higher level concepts that can be used to represent real-world objects, locations, users or information attached them, like documents, annotations, user profiles, etcetera.
- The third layer provides the means to define activities, define application logic and processes, and combine the context metadata to take higher order decisions on the basis of semantically enriched data (from layer two). In this layer the educational processes based on the pedagogical paradigm in the reference model can be defined. Furthermore, the information flows and conditions for the delivery of content are defined here. Moreover, the adaptation to the user's personal preferences or physical objects the user interacts with, happen in the third layer.
- The fourth layer carries out actions and delivers the electronic media based upon the decisions that have been taken in layer three. This layer also chooses the correct actuator and suitable content for a certain situation. In short, the purpose of this layer is to carry out an action or change a real-world situation that is given by the last column.

Figure 1 illustrates the technical framework when these four layers are combined and integrated with learning networks software.

Figure 1. A technical framework integrating contextualised media and learning networks



The learning network and learning communities are integrated via the sensor and electronic media layer on the one hand, and the actuator/indicator on the other. Knowledge Resources created in a learning community are delivered as electronic media to the first layer. Similarly, activities performed in the learning network, information about a learner, and social connections are described using activity, individuality and relations context, which is send as input to the sensor & electronic media layer. After the sensor data and content has been processed in the second layer, an action can be carried out on the basis of a decision made in the third layer, the content-context modeling service. The decision is made on the basis of a strategy defined by a technical user or an educational practitioner. As described in the requirements, the technical user defines several low-level strategies concerning the data aggregation, content filtering, and control logic. These strategies are created using the situation and activity editor, the content delivery filter editor, and the notification strategy editor. Alternatively, the education practitioner defines pedagogical scenarios in a learning design using a learning design editor. Once a decision for a suitable action in a certain context has been made, the fourth layer chooses an output channel, i.e. an actuator or indicator that can carry out the action to the learner in the learning network.

Application Scenarios of the Framework

The contextualised learning network software described could be used to carry out several mobile social learning scenarios, two of which we will provide in this section. The first example will describe a foreign language learning scenario, while the second will portray the benefits of blended learning scenarios in learning health and safety aspects in a real-world construction engineering scenario. The examples will illustrate how learning in learning networks can be combined with authentic, more informal, and formal classroom-based learning scenarios. We will concentrate on the use of mobile devices to support learning in context.

Foreign Language Learning

Language is a typical example of something that is widely used across contexts. Language learning takes place in different settings, for example, in a structured setting in an official language course in a educational institution, or a more unstructured, and common day-to-day setting in which language is acquired in a random manner. Additionally, the type of language learnt depends on the situation; some require informal daily speech, while other settings, i.e. business negotiations, require more formal language. Furthermore, language learning is addressed towards a certain community, most often a community of native or near-native practitioners, which uses a community-specific jargon (Petersen & Divitini, 2005). Especially, in an increasingly international world, acquiring this community-specific language becomes more and more important. Particularly, non-native speakers have a demand for just-in-time, situation-specific vocabulary to communicate in a more effective and efficient way.

This cross-context, situation-specific, community-based, and just-in-time nature makes language learning an interesting domain to explore and illustrate the possibilities and problems of a multi-platform e-learning system. In this sense, Petersen & Divitini (2005) have identified interesting community-based scenarios that include the use of mobile devices for learning (Petersen, & Divitini, 2005). More specifically, they emphasise that learning in communities is important because the students need to: (1) learn in an authentic cultural context where the local language is used, and (2) practice using the language with native speakers. In addition, we feel language learning would benefit from blended learning, combining de-contextualised theoretic language lessons, with contextualised authentic learning scenarios. An example of a de-contextualised language scenario is a structured online language learning course, much like the one taught at schools that train grammar, use vocabulary lists, and structured repetition. Conversely, contextualised scenarios would tailor vocabulary- and useful phrase lists to certain situations in daily-life. Paredes, et al. (2005) already demonstrated the context-aware language learning tool, LOCH, which assists learners in tasks that have to be solved by interacting with native speakers in the real-world (Paredes, et al., 2005). LOCH enables learners to directly get into contact with their teacher by using PDAs. The teacher can view the learner's locations and decide to give location-specific feedback. Moreover, the learners can create contextualised information like written annotations and pictures.

In a multi-platform learning network like the one we described, several connecting language learning scenarios can be implemented. A language learning network would include a variety of different learning communities each involved in learning a different language. Each community would consist of a heterogeneous group of native, near-native, and non-native language learners that create, possibly contextualised, multilingual learning content. The creation of learning content can furthermore be combined with community-reflection where more competent learners review the work done by novices. Furthermore, learners should be helped in finding appropriate (native) peers and a community-of-practice that would help them in their learning process; in this case, it would be interesting to couple native speakers that want to learn each other's languages. In any way, active use of a language by discussing with native peers would be an important part of language learning in learning networks.

Next to the community learning described above, language learning would also be beneficiary to self-directed learning processes, possibly mediated with mobile devices. The developed scenarios should allow for memorisation and repetition of language constructs, help to learn from errors by self-reflection on preserved learning history, and combine de-contextualised and contextualised knowledge that results in applying the knowledge learnt. Furthermore, the learning network software should help the self-directed learner in planning, structuring, self-monitoring, and evaluation of learning. Mobile devices could mediate these processes, for example by structured delivery of learning content for memorisation and repetition (Attewell & Webster, 2005). Another example is language learning by interaction with real-world objects. The objects are enriched with language learning content, for example a text message describing the object, or an audio fragment containing a useful phrase related to that object that can be accessed using a mobile device. Thus, the interaction with the objects and learning content in an authentic situation allows learners to learn a language. Furthermore, learners can create their own language learning content connected to objects (De Jong, Specht, & Koper, 2007).

Summarising, language learning in multi-platform learning networks include the following activities:

- Acquiring language on the move, tailored to specific situations,
- Active use of the language, by communication with native peers,
- Creation of learning content, either contextualised or de-contextualised,
- Commenting on peers,
- Discussion with peers,
- Memorisation and repetition,
- Planning, structuring, and self-monitoring of learning,
- Learning by interaction in the real-world.

In addition, countless situations could be defined that are used to contextualise the available language content, for instance standard situations as introducing yourself, ordering at a restaurant, bargaining in a shop, etcetera.

Learning Health and Safety Aspects in a Real-World Construction Engineering Scenario

In construction engineering, students have to learn how to apply the theoretical knowledge in the curriculum to real-world construction work scenarios. While currently most of the teaching is theoretical and classroom-based, students would benefit by actually seeing the principles applied in real construction work. Not only does such an exploration give students the opportunity to encounter real-world examples of knowledge applied, it also actively involves the students in the learning process and compel them to apply the theory just learnt (Bruner, 1966). This application scenario gives an example to get most benefit out of practical learning situations by mediating on-the-spot health and safety risks management learning with mobile devices.

The scenario is based on a Health and Safety Management course, which is part of the International Master in Construction Project Management taught at the Technical University of Catalonia (UPC). The aim of this course is to provide basic knowledge of health and safety (H&S) risks identification, H&S preventive measures and H&S regulations. Therefore, the course provides the know-how that will enable the future construction project managers to analyse and identify the H&S risks existing on a real construction site, in a clear, concise and comprehensive way and to choose the better and more efficient preventive measures to solve these risky situations. In order for students to build a better understanding of the concepts contained in the course, it is important that all the concepts exposed in the theoretical lessons can be recaptured by the students in real-world construction site scenarios, for instance, by using smart phones capable of displaying rich media content.

The course scenario is divided in three modules. First, in module one, the instructor exposes all the theoretical contents stressing the importance of the real-world construction examples and the use of digital contents, existing in repositories in the web, easily accessible for students. Second, module two aims at developing a workshop based on a real construction site. Students are provided with drawings of the current real state of the building. Then, the group of students (maximum 15 people) is moved to the construction site, where the H&S risk manager guides them through the site. Students are asked to identify the existing H&S risks, and the applied or missing preventive measures which they should draw on the provided drawings. Digital contents exposed by the instructor in the theoretical lessons can again be viewed by using the smart phones which allow the owners to access their work and improve their learning outside of a normal classroom context. Additionally, students are also encouraged to take pictures of the applied or missing preventive measures to be used in a reflective session afterwards. Last, module three is aimed at collecting and sharing all the students' reflections and observations using the drawings, pictures or videos recorded during the visit.

At the end of the course, students have gone through all the theoretical concepts related to H&S management, they have been at a real construction site where the theory has been applied, and finally they are asked to assume the role of the H&S risk manager checking the security of the site. Most of the learning process can be supported by multi-platform e-learning solutions.

In contrast to the language learning scenario, learning health and safety aspects in construction engineering mainly involves:

- Learning the theory: using pre-designed units of learning about the health and safety aspects.
- Contextualised content creation: the creation of GPS annotated pictures and other learning content describing the health and safety aspect on-site.
- A reflection session in the classroom afterwards discussing the created content to learn from each other's learning content.

The dissemination of the learning theory and the reflection session could be supported by the learning network software, while the contextualised content creation is typically done with mobile devices. Three different situations are found in this scenario: the pre-visit classroom-based session, the exploration of a real construction site, and the classroom reflection after the visit. These three situations can mainly be distinguished using location and time context information.

CONCLUSION AND OUTLOOK

In this chapter, we looked at extending learning networks to include more ubiquitous, lifelong learning scenarios. Especially, we emphasised on blended and authentic learning scenarios and provided a technical framework for contextualised learning in learning networks. Furthermore, we described some tools and scenarios to illustrate how a ubiquitous learning scenario could be designed and implemented. Based on the technical and scenario realisation, a number of conclusions can be made.

The adaptation of multi-platform e-learning systems will largely depend on the ease of use and an easy integration into current day education. Moreover, these systems should provide a clear surplus value to more traditional learning scenarios; especially, the learners should see the benefits of the technology. Thus, the success of multi-platform technology for learning, in our opinion, largely depends on the provision of pedagogical models for blended learning scenarios clearly indicating the benefits of the technology use to both educators as learners. However, the success of multi-platform learning might turn out to be more learner-driven. The recent uptake of mobile devices has made access to web-based learning content, personalised information, and social networks available nearly anywhere, anytime and anyplace (Castells, et al., 2007; Rheingold, 2002). Therefore, driven by the learner demand, the current web-based e-learning systems could gradually evolve, via a combination of web-based and mobile applications, into multi-platform systems providing learner, context, and device-specific learning content.

Especially, the increasing popularity of social software like for example flickr.com, youtube.com, already illustrates that a lot of potential learners are willing to create content that can be viewed and used by others. In addition, in software as facebook.com and twitter.com learners provide a lot of information about themselves, their social peers, and their current activities. Moreover, most of this social software already is accessible via mobile devices and thus increasingly used in real-world settings far away from the desktop computer. With learners enthusiastic to create learning content for themselves and others, providing detailed personalised information, and constantly communicating their activities, highly personalised, social learning communities can be derived that also provide support in real-world settings, for instance by introducing nearby learning peers to each other, communication between learners at home and on the move, or looking at similar learning settings encountered by others in the learning community. In this paper, we gave a possible path to derive such a mobile social learning platform.

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